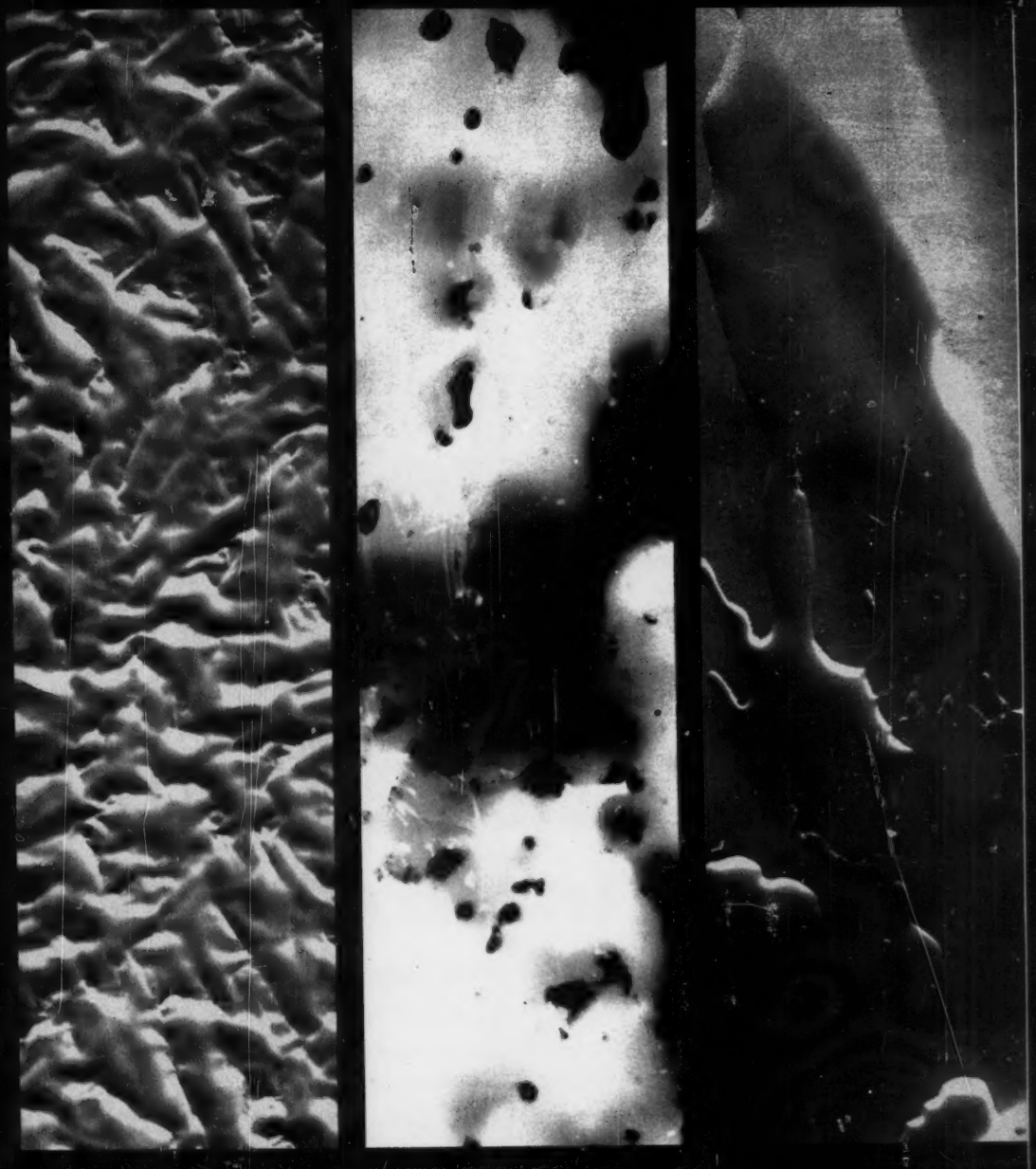
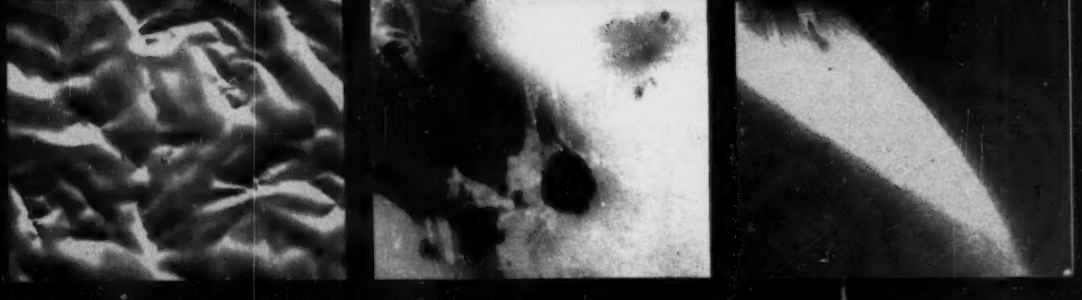
The Journal Of Environmental Engineering

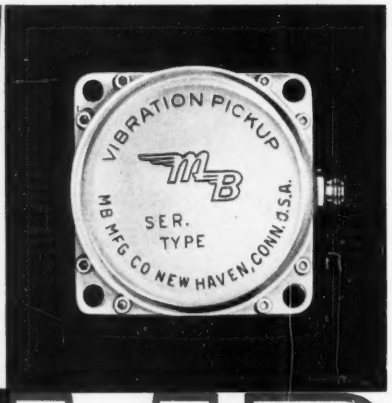




FEBRUARY 1959

SOCIETY OF ENVIRONMENTAL ENGINEERS

NEW MB



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The Journal Of Environmental Engineering

VOLUME 2 NUMBER 1

Published for active Environmental Engineers and the executives throughout industry who are concerned with the advancement of Environmental Engineering by the Society of Environmental Engineers.

Frank A. Kramer, Editor FEBRUARY 1959

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SEE Review For 1958

L. D. CARVER CHAIRMAN 1957-1958

Now that 1958 has drawn to a close, it is time to take stock of just what this year has meant to SEE. The most significant yardstick is the loyalty of the members. Surprisingly few have dropped out or failed to renew their memberships. These have usually been because of moving to some other location or changing type of occupation. This has been even more encouraging in view of accelerated activity in this area by a competing environmental organization.

We were all saddened by the news of the death on January 12 of one of our most active charter members, Bill Nestor. We miss him and wish to here pay tribute to him for his service to the Society.

Having outgrown the space at Rand's Round Up, we changed our meeting place for 1958 to the Rodger Young Auditorium. At our first meeting the new officers and board members were installed. One of the first actions of this new group was to submit a questionnaire to the members. The results of this were used to guide the Board in organizing the year's activities.

A diversified series of programs was provided. These covered the fields of man's exposure to vacuum conditions, data processing, random wave vibration, low temperature simulation, acoustical environments, rocket development, and designing for environment. To obtain the best presentation of each subject, several methods were used, including single speakers, panel speakers, and movies. A more complete description of these programs appears elsewhere. We wish to thank the speakers for bringing to us the benefit of their experiences.

The By-Laws were reviewed, and only a few minor changes were found to be necessary. These were approved by the membership.

One of the successful special events for the year was a field trip on January 13 to the Litton Industries' large walk-in altitude chamber. Approximately eighty people enjoyed the demonstration and discussion of this research facility designed to study man's problems for survival in a high vacuum.

Another was the joint meeting with ISA and ASQC on April 22. Mr. Fred R. Semark, Chief Vibration Engineer of the W. Bryan Savage Co. in London, spoke on the "British Approach to Vibration Testing". Mark Christensen, our Vice Chairman, was in charge of arrangements for all three societies and did a really fine job, as the 175 people who attended will verify. Not only did we gain much from the talk by Mr. Semark, but he was very interested in our Society. Before leaving, he and two of his associates were given complimentary memberships in SEE plus all the literature available to help them organize their own group. Thus, SEE gained International status.

Through the courtesy of the F. J. Stokes Company, a "Vacuum Calculator" slide rule was distributed to all members. This will be followed by other technical data from time to time.

Continued on page 28

Environmental
TEST LOADINGS OF MISSILE COMPONENTS and ASSEMBLIES

...up to: 150 G
8,000 lbs.
400,000 G-lbs.

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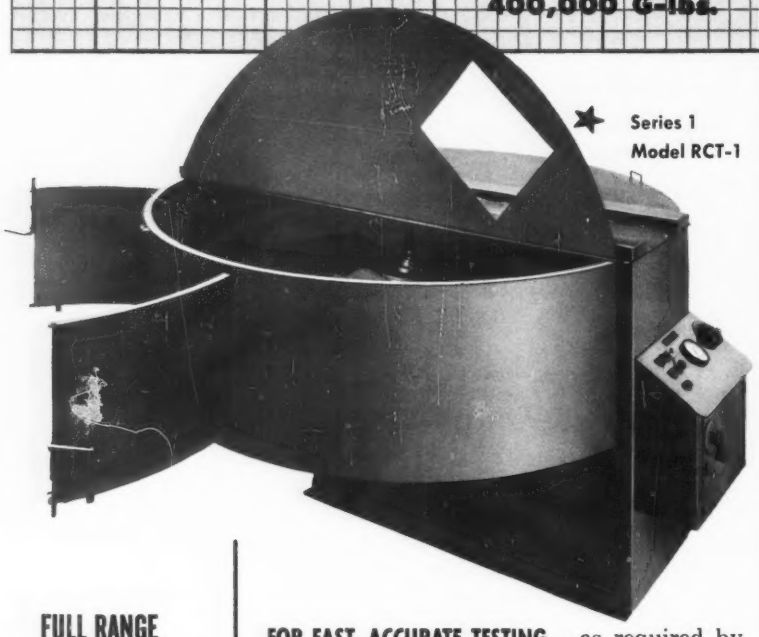

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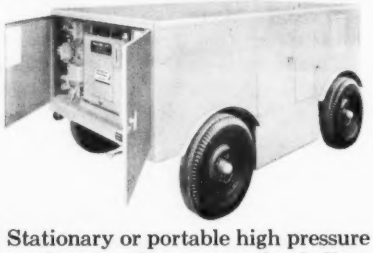

Stationary or portable high pressure gas boosters for compressing helium or nitrogen up to 6000-10,000 p.s.i. for missile development and production testing or flight line checkout.

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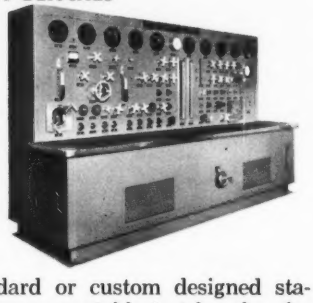

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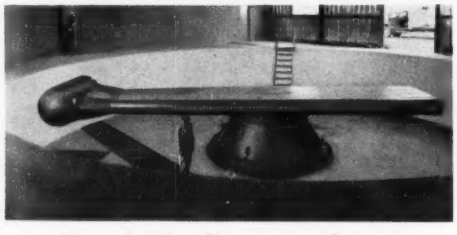


View of 22′ radius arm and powerhead installed in test pit. This large Series 20 unit is designed for testing 4,000 lb. specimen at 100 G-rating.

CHARLES T. MORROW

SPACE TECHNOLOGY LABORATORIES, INC.
LOS ANGELES 45, CALIF.

Charles Morrow has an A. B. degree in physics, an S. M. degree in communication engineering and an S. D. degree in communication engineering and acoustics, all from Harvard University.

He has been previously employed at the wartime Harvard Electro-Acoustic Laboratory, the Sperry Gyroscope Company, and the Hughes Aircraft Company. He has contributed to speech acoustics, the theory and design of gyroscopic devices utilizing vibratory members, the development of electronic and electromechanical devices, and the theory and applications of shock and vibration. In particular, he was partially responsible for the introduction of random noise theory and complex-wave testing to shock and vibration engineers.

Techniques for Design to Shock and Vibration Conditions

Abstract

Whether the critical environment is periodic vibration, random vibration or shock, the design of equipment for adequate reliability in a missile application is dependent on control of resonance so that the environment does not undergo large successive amplifications during transmission from the mounting points to the point of malfunction or damage. One method of doing this is to design so as to minimize the number of successive resonances the environment can pass through. Another is to stagger the frequencies of the successive resonances. For amplifiers and other electronic equipments, reliability can be gained, and dynamic analysis can be simplified by setting the part resonances in one frequency range and the chassis resonances in another; for several reasons, it is preferable for the chassis resonances to be the higher in frequency. For equipments so large that this can not be adhered to strictly without an excessive weight penalty, it may be possible to achieve a satisfactory compromise by designing the initial portion of the environmental path from the mounting points as a path in which the mechanical impedance does not decrease. If isolation mounts are to be used, the equipment and mounts should be designed as a system; mounts are not a cure-all for bad mechanical design. It is probable that the resonance frequency of the mounts should be higher than that of mounts commonly in use at present.

Coupled resonators

It is evident that a major portion of the problems of shock and vibration damage are related to the dynamics of coupled mechanical resonators, or, to state it differently, the dynamics of a complex resonator having two or more coupled degrees of freedom. Amplifiers and electromechanical devices as used in missiles or aircraft are exposed to shock and vibration over a wide frequency range that includes the first several frequencies of resonance of the chassis and of the internal parts. For example, suppose that a relatively massive chassis as tested on a vibration table exhibits a structural resonance at 200 cps with a Q of 50*, and on this chassis near the antinode is a small resistor also resonant at 200 cps. If the excitation of the chassis by the vibration table is 3g at 200 cps at the mounting points, the excitation of the resistor is not 3g but approximately 150g. Such a coincidence of resonance frequency is clearly undesirable.

More generally, it can be said that damage to a component such as an electronic chassis is especially likely when

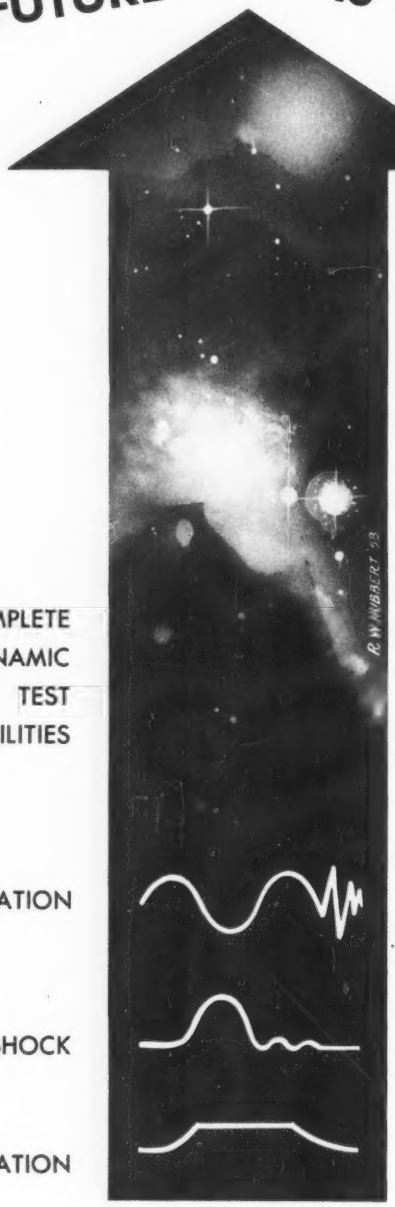
1. the path of the shock or vibration through the component includes successively two or more coupled resonators.
2. the path is in the direction of *decreasing* average mechanical impedance**.
3. the frequencies of resonance along the path coincide or are closely grouped.
4. the resonators are only lightly damped.

Furthermore, under such circumstances, it is possible for variations

**A "Q" is a dimensionless parameter equal to the ratio, at the resonance frequency, of mass reactance ($2\pi fm$) to mechanical resistance (c) for a simple mechanical resonator or for a mass exhibiting some dissipation of energy under vibration; or the ratio of spring reactance ($k/2\pi f$) to mechanical resistance for a spring.*

***The mechanical impedance is the ratio of applied force to velocity produced at the same point.*

THE FUTURE - - - IS OUR BUSINESS



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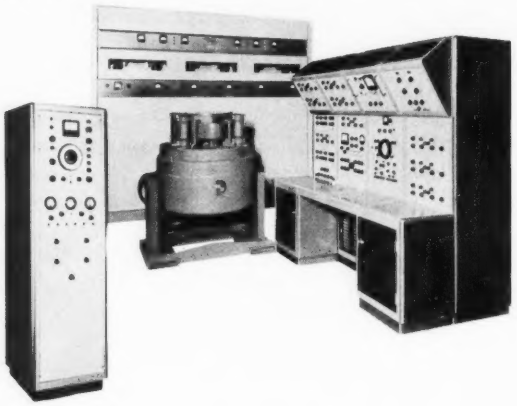
DYNAMIC
TEST
FACILITIES

VIBRATION

SHOCK

ACCELERATION

UNITED announces the addition of a 3500 force-pound MB Electronic Vibration system equipped to do RANDOM VIBRATION.



MB-C-25H ..... 3500 force-pounds*
MB-C-10 ..... 1200 force-pounds*
MB-C-5 ..... 650 force-pounds
All American Mechanical Shaker
*with RANDOM Vibration

MIL-S-4456 Barry Tower
JAN-S-44 Calibrating Spring Drop
MIL-STD-352 and 305, 40 foot Drop Tower
MIL-STD-350 Jolt and Jumble Machine

6 ft. radius, to 4000 force-pounds

THE ABOVE AVAILABLE WITH
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—: Fluid Flows (helium, nitrogen, liquid gases, oils, hydrogen peroxide, fuels):
—: Dust Controlled LOX Clean Room (temperature — humidity control, pressurized, double entry doors).

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of resonance frequency of ten percent in the course of manufacturing to make an order of magnitude difference in sensitivity to shock and vibration.

The example given was somewhat extreme but included only two resonators. The excitation was sinusoidal; the effective amplification of shock and random vibration might be somewhat less. It was implied that the resistor was light by comparison with the chassis and did not load the chassis significantly at the chassis resonance; or, more precisely, the resistor was of lower mechanical impedance at its mounting point than the corresponding mechanical impedance of the chassis. The damping of the chassis was chosen relatively low, but not uncommonly so. The example suggests that extreme fragility may result on occasion if a component is not visualized and treated as a dynamical system in the course of its design.

There has been some tendency in recent years to try to express shock and vibration in terms of an equivalent *static* acceleration. This works quite well for shock when the hardware excited contains only simple resonances.* For more complicated hardware, an equivalent static acceleration is more difficult to establish and may frequently be misleading since it would tend to focus the designer's attention on direct control of stress concentrations when he should fix his attention on the properties of resonances.

The usual practice of patching up the design in the course of tests on the vibration table tends to spread the frequencies of resonance so as to minimize amplification, although individual changes may not always have this effect. If the resistor in the example given failed during test, the designer would probably stiffen it and this would detune it. However, if the resistor resonance were on the low side of the chassis resonance, the first attempt at a remedy for failure might make things somewhat worse. Moreover, detuning the resistor from one resonance of a chassis may bring it into coincidence with another. A final word of caution is appropriate: the resonances of a chassis structure fastened to a rigid vibration table and tested to a prescribed acceleration may not be the same as those that occur in the service application.

These considerations suggest that it would be appropriate to place emphasis on some design practices that would result in a more adequate design prior to environmental test on the vibration table.

Damping

The use of heavy damping is an important technique of control of resonant amplification and should be explored and considered wherever it is feasible. However, there are some situations that demand exceptional dimensional stability or ease of degassing of materials, and make the application of damping difficult. The technique will not be emphasized in the remainder of the paper, not because it should be neglected, but because one objective of this paper is to call attention to other techniques whose virtues have been less obvious.

Decoupling

One technique that should be used insofar as it is feasible is the

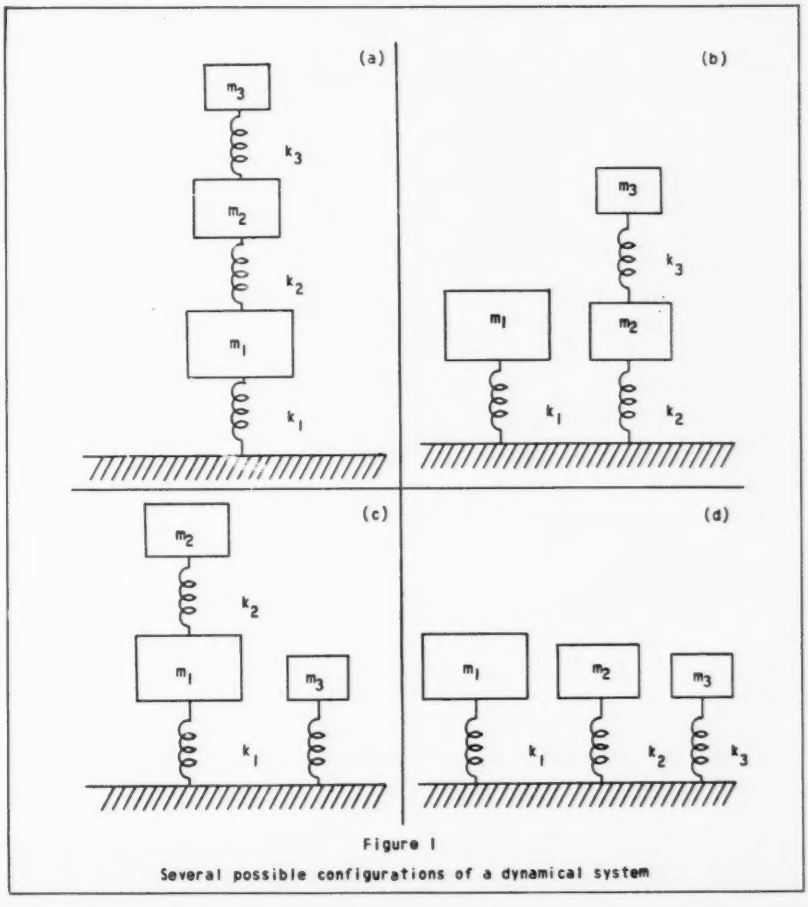
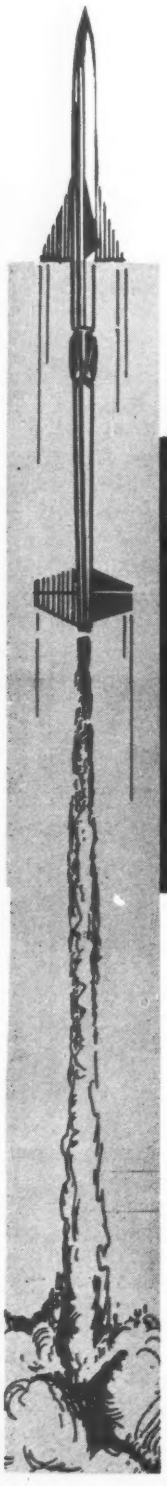


Figure 1
Several possible configurations of a dynamical system

*Reference 2

flight testing on the ground

Environmental and Performance Testing for Quality Control, Reliability, and Qualification of Electrical, Electronic and Electro-Mechanical Components, Sub-Assemblies and Assemblies



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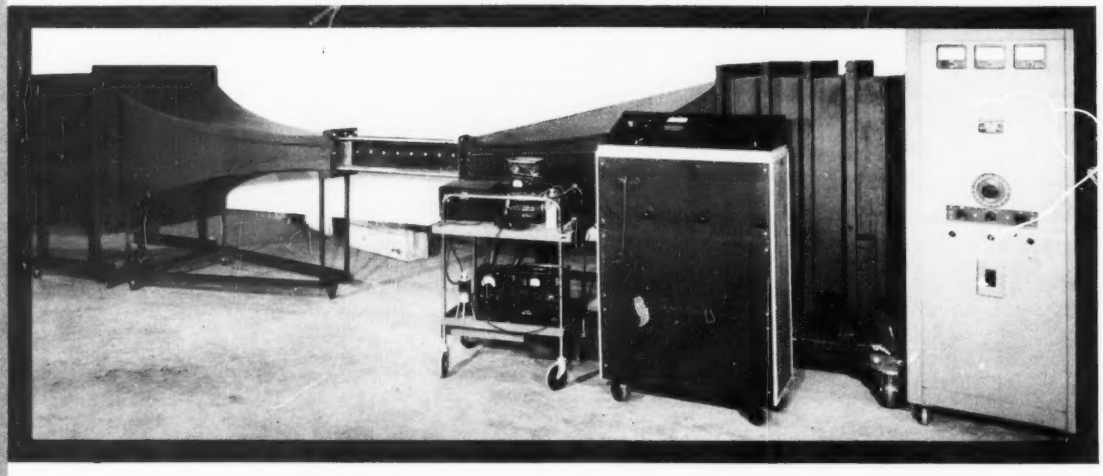

Acoustical vibration has recently been found--by the major airframe and missile manufacturers--to be an environment of prime importance in structures and electronic gear associated with jet and rocket engines. Rototest has developed and has operational a complete facility for testing components in high intensity sound vibration; much exceptional behavior has already been found in parts subjected to this environment.

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decoupling of resonances, or, in other words, decreasing the number of coupled resonances the environment can pass through on its way to important points of stress concentration. For example, if possible, a resonant part like a resistor supported on its leads should be mounted directly to the chassis rather than to some other member that is in turn mounted to the chassis. Several possible configurations of some of the masses and compliances in an item of equipment are illustrated in Fig. 1. The first (a) is ordinarily the most susceptible and the last (d) the least susceptible to damage by shock and vibration. Cementing or otherwise fastening the body of a resistor or capacitor to the chassis also tends to result in a favorable simplification of dynamics.

Detuning

In practical equipment used in missile and airplane applications, ordinarily, not all the equipment's resonances can be completely decoupled by changes in configuration alone such as are illustrated in Fig. 1. When two or more resonators must remain physically coupled, more margin of safety can be ensured by detuning them.

Electromechanical and hydraulic devices are ordinarily relatively rigid, with few resonances except at high frequencies. It is probable that they are simple enough dynamically to make it feasible to protect them against damage by a straightforward technique of calculating and rearranging of resonance frequencies. Electronic chassis, on the other hand, as conventionally designed, are complicated dynamically, have many more parts, and have a discouraging lack of symmetry, so that a more drastic and simple approach to the de-tuning process may be required. Fortunately, the dynamical properties of an electronic device are subject to fewer functional restrictions than are the properties of electromechanical hydraulic devices.

The effective dynamical design of an electronic chassis would be simplified by prescribing certain frequency regions for the resonances of the parts as mounted, and other non-overlapping frequency regions for resonances of the structural portions.* For a simple example, the resonances of the structural portion might be prescribed in a high frequency range and those of the parts in a much lower one, or vice versa.

In the ruggedization of vacuum tubes, it is common to stiffen them, and it is common to use short leads on resistors and capicators when they must withstand shock and vibration. It is possible to show that in some circumstances an opposite trend might be preferable. If the structural portions of the chassis are also stiffened there is again a possibility of coincidence among the resonances.

Fig. 2 shows a resistor with short leads mounted to a flexible structure, and Fig. 3 shows a resistor with longer leads mounted to a structure whose first resonance is at a much higher frequency than that of the resistor. A resistor mounted by its leads behaves much like a lumped constant system and is unlikely to have a second major resonance within a factor of three or more of the first. The structure, on the other hand, can be represented only by distributed constants and is likely to have higher modes of vibration close to the first frequency of resonance. Thus, the resonance of the resistor with the short leads may be directly excited by a higher mode of the chassis structure, whereas separation of resonances is virtually guaranteed in Fig. 3.

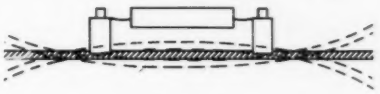

Figure 2
Resistor with short leads on flexible terminal board

Figure 3
Resistor with longer leads attached to rigid structure

Suppose that this direct excitation of the resistor resonance does not occur. The resistor with the short leads is still subject to another difficulty. When the structure vibrates at its first mode, it flexes, and this can result in stress in the leads even though the acceleration of the resistor is not further amplified by resonance. In fact, the shorter the leads, the greater the stress.. *For these reasons, it is preferable to have the first resonance of the chassis higher than those of resistors and capacitors as mounted by their lead wires.*

For vacuum tubes, which are more complicated dynamically than resistors, it is not clear that quite so simple a rule is optimum, although the tube leads must be protected from stress, and excellent results through rigid chassis design have been obtained by Comuntzis.*

**Current vibration specifications merely require the application vibrations, described in terms of acceleration, as forcing functions, but provide no explicit control of resonance frequencies. The same accelerations are ordinarily applied to components, assemblies, subassemblies, and parts.*

**Reference 4*

Continued on page 18

1200° F. WALK IN TEST CHAMBER
6' X 8' X 6' CHAMBER
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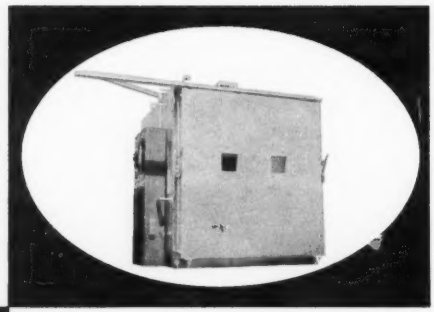

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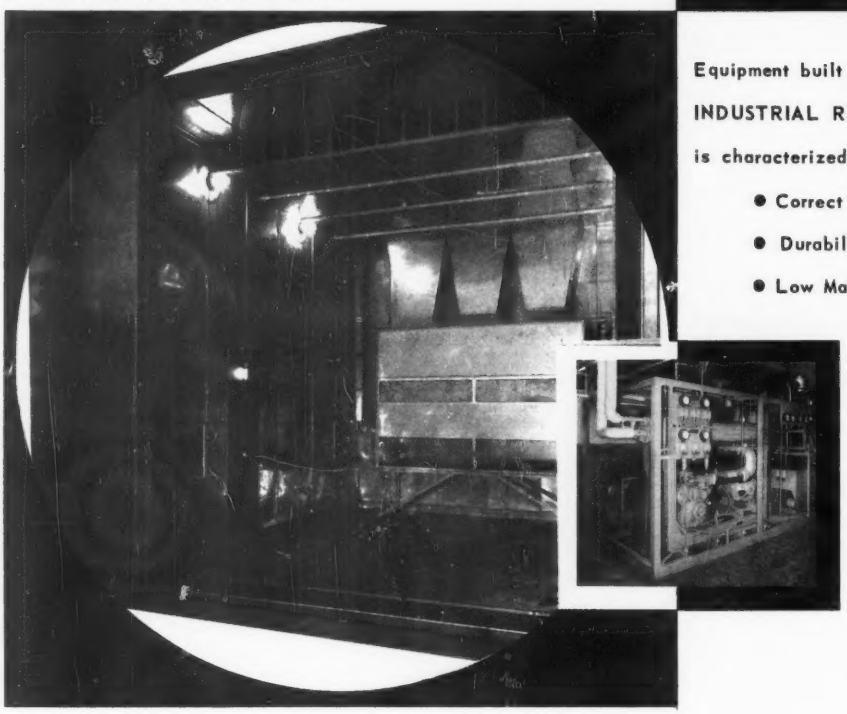

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THE IMMERSION TEST SET

VERNON L. BRADFIELD

TEST SUPERVISOR
COLLINS RADIO COMPANY

One of the many time-consuming problems faced by environmental engineers, is the problem of testing the efficiency of moisture seals of electronic units. Items produced under military contracts are required, usually, to pass the immersion test, Method 104A, of MIL-STD-202A. A semi-automatic test-tank, designed for use at Collins Radio Company, provides a quick and accurate means of accomplishing such a test.

MIL-STD-202A requires that a unit be subjected to successive cycles of immersion, each cycle consisting of immersion in a hot bath of fresh (tap) water at a temperature of 65° $^{+5°}_{-0°}$ C (149° $^{+9°}_{-0°}$ F), followed by immersion in a cold bath, the number of immersion cycles, the duration of the cycle, and the nature of the cold liquid, are specified for various types of test, as required for the subject unit by the contract involved. The immersion test is usually performed after physical and environmental tests have been made, since these latter tests tend to aggravate any previous defects in seals, seams, or welds that are intended to isolate internal chambers of a unit from atmospheric conditions. An immersion test is intended to detect any migration of liquids permitted by such faulty sealing.

In a test facility such as ours at Collins Radio Company, it is necessary to evaluate the adequacy of the seals of numerous transformers, capacitors, resistors, and similar electronic components. Therefore, a fast and realistic means of meeting test requirements is of extreme importance.

Before the new immersion test-tank was provided, the test procedure required an assortment of beakers, immersion heaters, agitation devices, thermometers, thermostats, and timers. A considerable amount of time was required to set up and conduct each test. For example, it was necessary to add ice to the liquid as required for temperature control. Another problem was the constant observation to insure cycling of immersion at specific intervals. The situation was compounded by the number of units requiring verification in a limited time. And in addition to the questionable accuracy and production problems involved, much of the attending technician's valuable time was wasted.

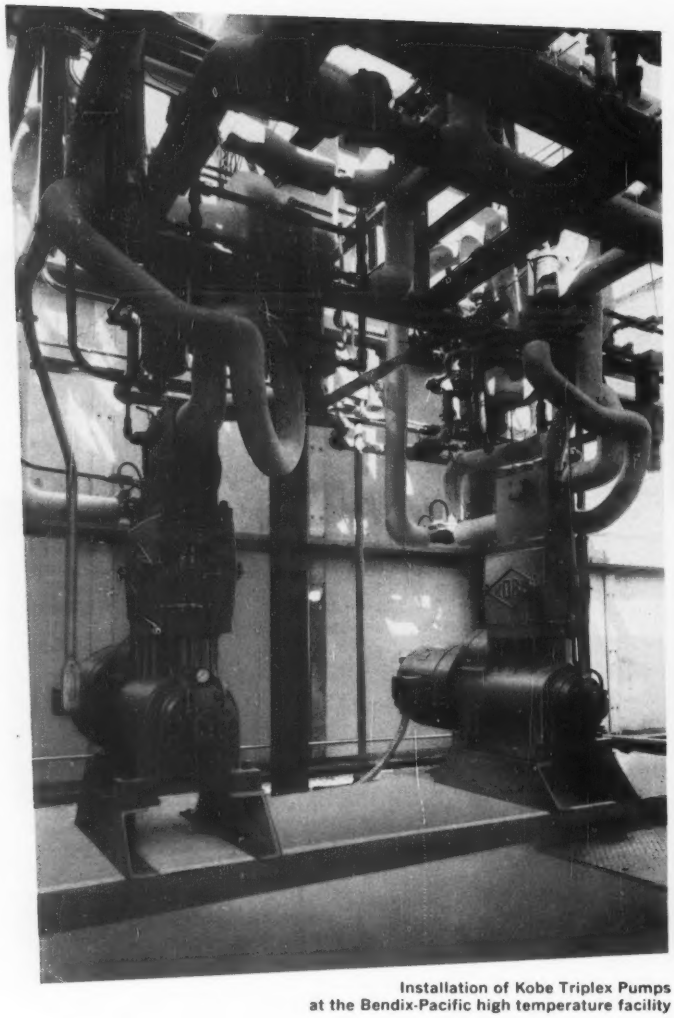
After an evaluation of the problem, it was decided to construct an immersion test set that would do the job more efficiently. A list was compiled of the features required in such a tester. For our purposes, it appeared that the test set should provide:

1. Two tanks large enough to hold all types of components normally encountered in our work.
2. Adequate heating and cooling of bath liquid to maintain required temperatures, particularly in cases where components having large thermal-storage capacities are transferred from one environment tank to the other.
3. Adequate control and monitoring of temperatures.
4. Simplicity in filling and draining containers with tap water.
5. Adjustable repeat-cycle timer to limit duration of each immersion cycle.
6. Automatic transfering of components from one tank to the other, as rapidly as possible, in conjunction with repeat-cycle timer.
7. Automatic termination of test and shut-down of equipment after a predetermined number of cycles.
8. Agitation of water to provide more constant temperature control to maintain suspension of sodium chloride when required, and to prevent the accumulation of ice (caused by the close proximity of refrigeration coils) around the outside edge of the low-temperature tank.
9. Ability to handle up to a 20-pound component.

The finished test set, shown in Figure 1, adequately meets all requirements for our purposes. In approximately five minutes, a technician can set up the tester for a batch of units, since this involves simply filling the tanks and setting the timer and cycling switches. The tester automatically controls the temperature of the bath in both tanks, limits the immersion time and transfers the basket of units between the two tanks in accordance with the setting of the cycling switch. At the end of the test, the basket comes to rest suspended in the air, mid-way between the two tanks.

Some thought has also been given at Collins toward designing a tester, using similar principles, to facilitate compliance with MIL-STD-202A Method 102A (temperature cycling) and Method 107 (thermal shock).

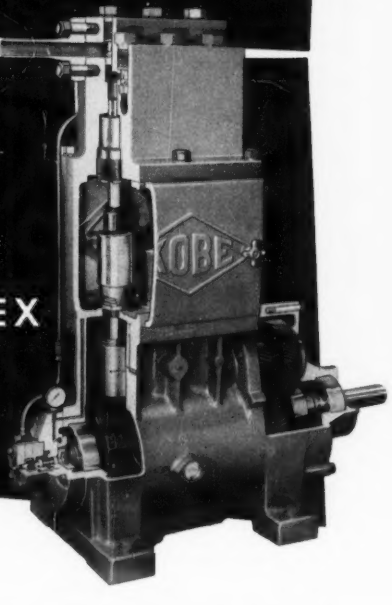
These details are presented purely to stimulate thought on the subject, and to make available to other environmental engineers the information we have accumulated in the hope that it may be of value to them. ▲



Installation of Kobe Triplex Pumps
at the Bendix-Pacific high temperature facility

THE HOT PUMP ANSWER *for high temperature hydraulic testing*

The **KOBE TRIPLEX** *Pump*



Over the past two years the Kobe Triplex pump has been proved capable of pumping hydraulic fluids at temperatures ranging from −65°F. to 550°F., at pressures up to 5,000 psi. Two different companies have each logged more than 1,000 hours on a Kobe Triplex at temperatures in excess of 400°F. Neither of those two installations nor any other in high temperature service have experienced any repair or replacement problem.

The Kobe Triplex is characterized by having metallic gaskets for all static seals in the fluid end, and by a metal-to-metal lapped fit on the plungers and liners. There is no requirement for cooling any part of the pump in high temperature service.

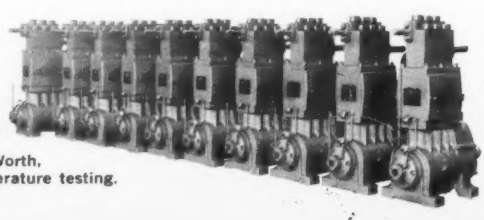
When used in a high temperature facility, the Kobe Triplex eliminates the requirement for a high pressure heat exchanger. The pump permits the design of a test stand with a minimum of fluid in the system and thereby minimizes the maintenance cost of periodically replacing expensive hydraulic fluids. Technical data on request.

Also pumps for

HYDRAULIC COMPACTION
STRESS ANALYSIS
TESTING PRESSURE VESSELS

In addition to the standard 5,000 psi units, Kobe Triplexes are available with pressure ratings of 10,000 psi and 20,000 psi, and a 50,000 psi version is now being developed. These are suitable for use with oil or water with soluble oil.

We will, of course, welcome an opportunity of quoting on your requirements. Please call or write –



Recent shipment
of 10 Kobe Pumps
for Convair, Ft. Worth,
for high temperature testing.

KOBE INC.

AIRCRAFT SALES DIVISION

3034 E. Slauson Ave.
Huntington Park, Calif.
LUdlow 8-1271

815 Superior Avenue
Cleveland 14, Ohio
CHerry 1-5633

YEAR END REPORT

OF THE SOCIETY OF ENVIRONMENTAL ENGINEERS

OFFICERS

L. D. Carver (High Accuracy Products Corp.), *Chairman*
M. S. Christensen (Firestone, Guided Missile), *Vice Chairman*
A. H. Marshall (Autonetics), *Executive Secretary*
H. F. Rayfield (Electrodata), *Recording Secretary*
J. Bakalish (Firestone, Guided Missile), *Treasurer*

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N. S. Biship (Northrop), *Programs*
J. S. Elledge (Auto-Controls Labs), *Standards & Specifications*
F. A. Kramer (Space Technology Labs), *Publications*
W. L. Vandal (Autonetics), *Past Chairman*

INTRODUCTION

This is our second Year End Report, although it is practically the end of the third year of S.E.E.'s existence! It is interesting to dig back into last year's Report to recall some of the earlier struggles incurred in forming the Society - and to compare to this the rather smooth sailing of the past year. Our organization is now thoroughly sound and duly recognized as a first-rate technical society. And all members have had unparalleled opportunities to benefit, through the technical presentations made at our meetings, and through the numerous associations and contacts made between men of like interests!

THE COMING YEAR

J. BAKALISH

As your new chairman, I have been asked to write of our society's objectives for 1959. To do so, it is necessary to point out that one of our goals will be to help complete several programs established by previous BOARDS.

It is difficult, before all your new officers are elected and installed, to formulate a firm program. However, for some time, several board members have spoken of "keeping the membership better informed of board meeting decisions and happenings". With this in mind, I hope to establish a regular column, as a feature of our new JOURNAL, reporting the proceedings of our board meetings. At this time, I am unable to say who will write the articles, how they will be written and/or suggest a suitable name for the column. But, be assured that each issue will relate the happenings of the previous month's meeting.

In the meantime, I'd like to focus your attention to *excerpts* from our "blue" AIMS FOLDER.

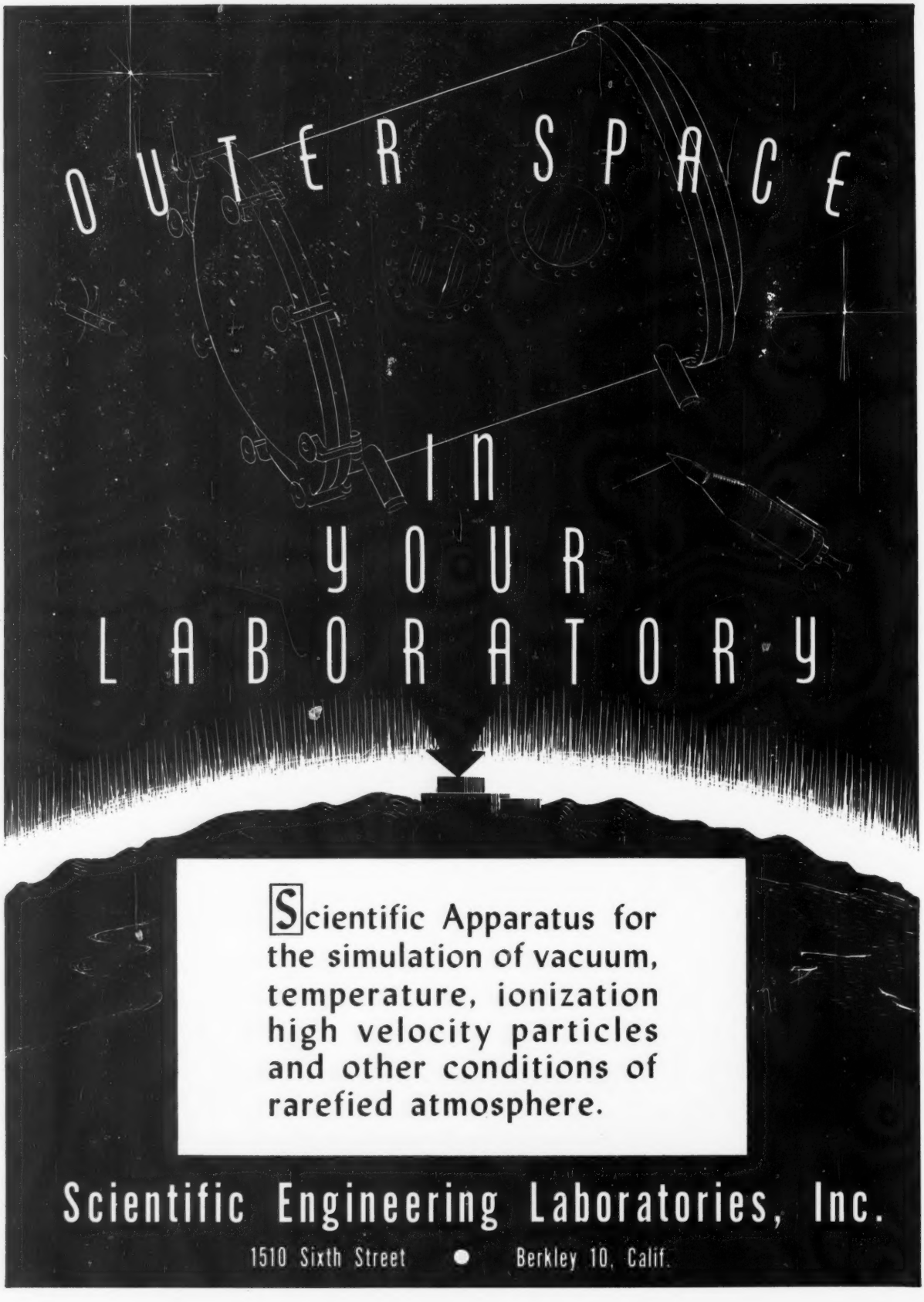
"The S.E.E. is an influential group of scientists, engineers and technicians, who realized the necessity for proper recognition of the environmental engineer and his profession. (THIS ORGANIZATION HAS AS ITS SOLE PURPOSE, THE ADVANCEMENT OF ENVIRONMENTAL ENGINEERING. IT EXPECTS TO ACCOMPLISH MUCH THROUGH CONCERTED ACTION.)

"We ask you to accept this invitation to join with others of like mind and training, to strengthen the Society and its objectives with your membership and active participation."

During the past three years, energetic leadership and active participation of our members has advanced us in this direction. Further, we have enhanced the reputation of our Society with substantial growth in both actual membership and number of firms represented thereto.

For the coming year, your Directors and Members-at-Large sincerely hope that each member, will join with them, in reaffirming to the "purpose" of our organization and its pledge to work together for its fulfilment.

Continued on page 13



Scientific Apparatus for the simulation of vacuum, temperature, ionization high velocity particles and other conditions of rarefied atmosphere.

Scientific Engineering Laboratories, Inc.

1510 Sixth Street • Berkley 10, Calif.

Continued from page 11

MEMBERSHIP COMMITTEE REPORT

O. G. BAER

On 1 February 1958 the membership of the Society of Environmental Engineers was 142 and through the past eleven months has grown to 156 active members (as of 1 January 1959) representing some 81 companies in the Aircraft, Missile, Commercial Testing Labs, and Electronic Industries. During the year, 85% of the members renewed their membership in the Society. In the past eleven months a total of 36 new members have been accepted into the Society.

Geographically the Society is composed of members from areas (other than Los Angeles) such as San Diego, Santa Barbara, San Francisco, Palo Alto, Denver, Massachusetts, and honorary members in England.

The average attendance at the bi-monthly meetings has been approximately 130 with a high of approximately 200 attending the Acoustical Vibration meeting.

PRE–AUDIT SURVEY & BREAKDOWN OF EXPENDITURES & EXPENSES, MARCH THROUGH DECEMBER, 1958

I. EXPENDITURES

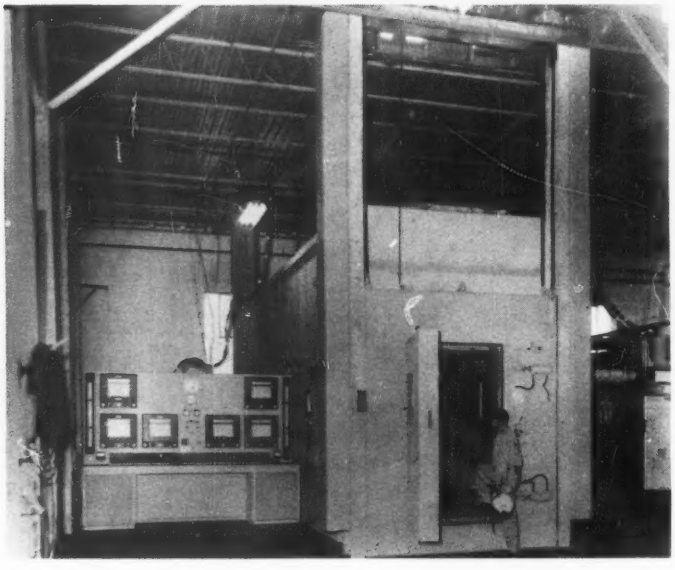
1958 Month	Postage	News Letter	Printing	Speaker's Dinners	Dinner Deficits	Misc.	Petty Cash	Photo Services	Printing Journal	Formal Audit	Monthly Totals
George Beaton, Treasurer during Jan. & Feb.									Books audited as of Feb. 28, 1958.		
March	2.90	94.97	2.50			7.50	3.37			75.00	$ 186.24
April	10.00	181.84		7.50		5.00	.99				204.83
May	12.70		117.80				1.00				131.50
June	1.50	53.26		17.50			11.00	23.40			106.66
July				NO EXPENDITURES							
August	9.16	136.63		3.50		16.75	1.56				167.60
Sept.	22.50		176.80				6.75				206.05
Oct.		27.41	18.20	21.00				23.40			90.01
Nov.	43.90						1.00		A/C 500.00		544.90
Dec.					70.25	15.52	.40	8.00	655.80		749.97
ITEM TOTALS	102.66	494.11	315.30	49.00	70.25	44.77	26.07	54.80	1,155.80	75.00	
									TOTAL EXPENSES		$2,387.76

II. INCOME

	MEMBERSHIP AND DUES				***JOURNAL***		
	No. of New Members	Amt. of Dues	Renewal Dues	Lapel Pins	Advertising	Subscriptions	Monthly Totals
March	7	84.00	467.00	(11) 19.25		@ 5.00	$ 570.25
April	–		24.00			each	24.00
May	4	48.00	133.00	(7) 12.25			193.25
June	1	12.00	49.00				61.00
July	9	108.00	66.00	(2) 3.50			177.50
August	2	24.00	45.00				69.00
Sept.	3	36.00	18.00	(2) 3.50			57.50
Oct.	1	12.00	15.00				27.00
Nov.	6	72.00	4.00	(3) 5.25			81.25
Dec.	2	24.00	1.00		484.89	10.00	519.89
ITEM TOTALS	35	420.00	822.00	43.75	484.89	10.00	
					TOTAL INCOME		$1,780.64

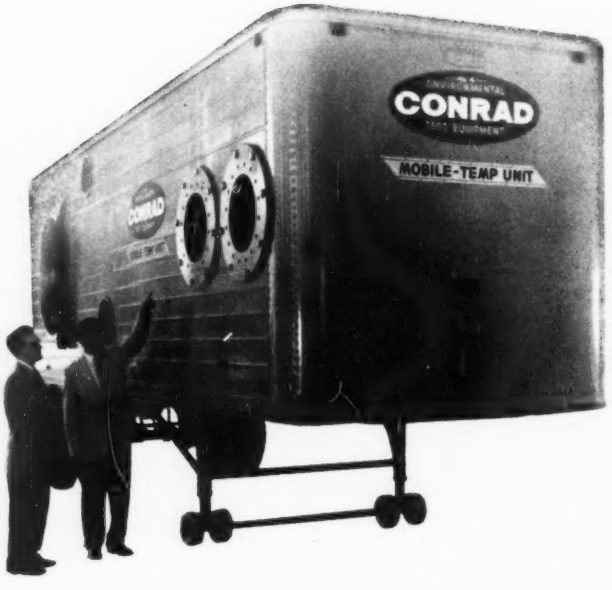
Continued on page 16

For CONRAD Inc. Sales and Servi



1200 CU. FT. WALK-IN. This Conrad chamber is sectionalized to permit testing at high and low temperatures simultaneously. Range: —120°F. to +650°F., altitudes in excess of 125,000 ft. Capable of dissipating 40,000 watts at —100°F. Complete unit is prefabricated in three sections—main chamber, machinery, and instrument panel. Main chamber consists of two chambers with port in separating wall. In typical test, missile component is installed in port which is then sealed so high and low temperatures may be applied to different sections of component simultaneously.

MOBILE-TEMPERATURE UNIT. Conrad ingenuity designed this mobile unit to supply conditioned air. Range, —100°F. to +300°F. Supplies conditioned air, by self-contained pressure blower, for testing missile or other object in a separate chamber or temporary housing. Connects to facilities power source or portable power generator truck. Model illustrated is equipped with a 50 h.p. refrigeration system: other sizes available according to requirements. Iconel sheathed electric heaters handle rapid changes in high temperature demands.



CONRAD Inc.

HOLLAND, MICH.

Subsidiary, Crampton Mfg. Co.

ENVIRONMENTAL TEST CHAMBERS FOR ALL APPLICATIONS

Service On The West Coast, Call On

E. A. WRIGHT
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RYan 1-0181 **SYcamore 2-1485**

CONRAD Inc.

Pioneers In The Design and Manufacture of Environmental Test Chambers

Next time there's a question about environmental test chambers, check with Conrad's West Coast representatives. Take advantage of their convenient location and their complete service on all types of chambers—walk-ins, portables, and standard models for altitude, humidity, temperature, and temperature-vibration testing. Widely experienced planning and engineering, installation and service by a factory-trained staff.

FREE! New chart of technical information and conversion data. Address your request to E. A. Wright, address as above.

CONRAD CUSTOMERS

Among the many firms in the West Coast area where Conrad environmental test chambers are installed are the following:

Space Technology Laboratories
Ramo-Woolridge Corp.
Hughes Aircraft Corp.
North American Aviation
Douglas Aircraft
Convair
Minneapolis Honeywell
Northrup Aircraft
Ampex Corp.
Sandia Corp.
Lockheed
Sperry Rand Corp.
Jet Propulsion Laboratories
Aero-Jet General Corp.
Boeing Aircraft

Right: Portable vibration-temperature chamber, with hydraulic hoist.

Below: Conrad's long experience assures accuracy in production techniques. These are Conrad FB-64 and FD-64 models, with 4′ x 4′ x 4′ test space and temperature ranges from —100° to +300°.

SOCIETY OF ENVIRONMENTAL ENGINEERS
PRE-AUDIT STATEMENT OF RECEIPTS AND EXPENDITURES
FOR THE PERIOD MARCH 1, 1958 TO DECEMBER 31, 1958

RECEIPTS:		
Membership Dues	$1,242.00	
Sales of Lapel Pins	43.75	
Advertising & Subscriptions	494.89	
TOTAL RECEIPTS		$1,780.64
EXPENDITURES:		
Stationery & Printing	$ 315.30	
Dinner Guests	49.00	
Postage	102.66	
Newsletters	494.11	
Environmental Journal	1,155.80	
Cost of Audit	75.00	
Photo Service	54.80	
Petty Cash	26.07	
Miscellaneous	112.02	
TOTAL EXPENDITURES		2,387.76
NET RECEIPTS or DEFICIT		***$ -607.12***

STATEMENT OF ASSETS AND LIABILITIES
DECEMBER 31, 1958

ASSETS:		
CASH IN BANK	$ 212.58	
PETTY CASH ON HAND	23.93	
TOTAL ASSETS		$ 236.51
LIABILITIES:		
ACCOUNTS PAYABLE		NONE
CAPITAL:		
Balance, March 1, 1958	$ 843.63	
ADD, Net Receipts for 10 Months March 1, 1958 to Dec. 31, 1958	-607.12	$ 236.51

PREPARED BY:
J. Bakalish, Treasurer
Society of Environmental Engineers

STANDARDS AND SPECIFICATIONS COMMITTEE

J. S. ELLEDGE

At the beginning of the year, the major project was the completion of the Specification Centers. This project was started by Mr. Leon Carver, chairman of this committee for the previous year. A questionnaire was distributed and further investigations were conducted. With these results it became apparent to this chairman and to the S.E.E. Board of Directors, that this project would require a large amount of work by many people and would serve only a minority of the membership. Therefore, it was decided to discontinue the project in favor of several others.

An organizational meeting was held at the home of Mr. Harry Himelblau on June 19, 1958. At this well-attended meeting, the objectives and purposes of this committee were discussed and outlined as follows:

1. Review existing specifications and submit to the originating authority suggestions for simplifying, standardizing, or coordinating specifications in general use.
2. To assist reorganized agencies in the revision or formation of standards and specifications by supplying these agencies with what information is obtainable.

3. To develop and promote standards for environmental research and testing.

4. To establish and resolve problems of common interest.

A temporary steering committee was established to further organize the committee. It was decided that a problem - resolution approach was in order with the members divided into groups of about 8 to 12 men each.

Each group would have a leader whose responsibility was set forth as follors:

1. A written statement of the problem.

2. A rough outline of the proposed resolution to the problem.

3. Organization and assignment of work to committee members.

4. Preparation and presentation of the completed paper.

The next general meeting was held on July 21 at Whittaker Controls, 910 N. Citrus, Hollywood. Mr. Vern Roe was elected as recording secretary. After some discussion two groups were formed.

The first of these groups elected Mr. Robert Levine as it's chairman. For their problem they selected "A Study of Random-Sine Equivalents". Mr. Levine and his committee outlined this problem as follows:

1. Collection for study and analysis of previously prepared technical papers with special emphasis on equivalent formulas already developed.

2. Determine physical principles of derivation, and decide if there are any analogies.

3. Investigate method of applying equivalents.

This group has spent a large amount of time in study and analysis and expects to have a paper ready for presentation in mid-1959.

A second committee elected Mr. Seymour Seplow as it's chairman. For their problem the group has decided to write a paper on "Standard Procedures and Methods in the General Approach to Vibration". For the past several meetings a discussion and general evaluation of existing material has been carried out. The first draft of the paper is now being prepared by this group.

A questionnaire is now being prepared with the intent to find the areas and specific problems where this committee can best serve its members and the fields of environment. This questionnaire will be circulated both to members and non-members. The results and conclusions derived from this will be the guiding factors for operation in the coming year.

MEMBERSHIP LIST

*Abstein, Henry T., Jr.
Hughes Aircraft

Adams, William S.
Wyle Laboratories

*Anderson, Lawrence E.
Ryan Aeronautical Corp.

*Angelus, Paul
B. J. Electronics, Borg-Warner

Arndt, Leo A
Hoffman Laboratories Inc.

*Baer, Orville G.
Gilfillan Bros., Inc.

Bailey, Charles A.
North American Aviation

Bakalish, Jerome
Firestone Guided Missile

Baranoff, Albert J.
B. J. Electronics, Borg-Warner

Baumgartner, Barry
Packard Bell Co.

*Beaton, George N.
Hughes Aircraft

*Bishop, Noble S.
Northrop Aircraft Co., Inc.

Blais, Robert A.
Lockheed-MSD, Sunnyvale

Bouclin, Donald E.
Litton Industries

*Bradfield, Vernon L.
Collins Radio Co.

Bradley, Wilson, Jr.
Endevco Corp.

Braun, Michael J.
Wyle Research Corp.

Brennan, William J.
Pacific Scientific Co.

Briscoe, Harold D.
Cannon Electric Co.

*Britton, Howard E.
Hughes Aircraft

Broquist, William C.
Wyle Laboratories

Burke, Daniel M.
United States Testing Co.

*Burns, Elbert G.
Gilfillan Bros., Inc.

*Cail, John H.
Paul Hardeman Inc.

Canning, Richard H.
Cannon Electric Co.

*Carver, Leon D.
High Accuracy Products Corp.

Chadwick, James R.
Chadwick-Helmuth

Chase, James E.
North American Aviation

Chirinos, William J.
Hughes Aircraft

*Christensen, Mark S.
Firestone Guided Missile

*Clark, George F.
Missimers Inc.

*Cool, William
Stellardyne Laboratories

*Cotruzzola, Joseph P.
Hallamore Electronics Co.

Cox, Kenneth J.
Kennematt Co.

Crowley, E. R.
Weber Aircraft Corp.

Danielson, Charles W.
Litton Industries

Dargert, Homer D.
Rototest Laboratories

Debele, Walter P.
American Laboratories

DeKoven, Arthur J., Jr.
Mantec Inc.

Delaney, George C.
Amoux Corp.

Derr, William
Brubaker Electronics Inc.

DeTullio, John H.
Amoux Corp.

*Diggle, Frank V.
Hughes Aircraft

Dingus, Orville K.
Litton Industries

Dunleavy, Ann M.
Sargent Engineering Corp.

Edwards, Ted
Wyle Research Corp.

Elledge, John S.
Industrial Refrigeration

Continued on page 26

Continued from page 7

It is possible that in general case more than one frequency band for permissible resonance of parts must be prescribed. The question can probably not be settled until there has been a more comprehensive investigation of the resonances of parts such as vacuum tubes.

Furthermore, it should not be inferred that reliability is improved indefinitely by making the parts more and more flexible. This may, for example, move their resonances into a frequency region where the external environment is more violent, or where there is a danger of collision because of excessive displacement. Furthermore, the interior of a transistor has a higher order of rigidity than that of present vacuum tubes, and this rigidity should not be decreased. Likewise, cementing of resistors and capacitors directly to the chassis, and the clamping of heavy ones, are good practice.

On the other hand, the ruggedization of parts should not be carried out as a problem independent of the problems of chassis design.

The term resonance frequency has been used loosely in the foregoing without distinguishing between the resonances of the parts themselves as tested on a vibration table, for example, and the system resonances that exist after the component is completely assembled. When not stated otherwise, mention of a part resonance refers to the former, although there tends to be little distinction when fragility is most likely to be critical, namely, when loading of the terminal board or chassis by the parts is negligible. Imagine an electronic component approximated in terms of a set of lumped masses and springs. If the separation of the component into its parts does not cut through any of the masses or springs, the resonances of each part by itself are ordinarily considered to be those it exhibits when excited at the dividing point by an infinite impedance source if there is a spring at the dividing point, or by a zero impedance source if there is a mass at the dividing point. However, in a frequency range in which the mass or spring can almost be neglected by comparison with others in the part or in the mating part, it may be preferable to use a different convention. If a cut through a mounting point passes through the middle of a mass or a spring, it may be necessary arbitrarily to include or simulate the remainder in testing the part. For example, if a subminiature tube is mounted in a somewhat compliant clip, it may be necessary to measure the tube resonances as mounted in the clip..

If there is more than one mounting point in a part, the rigidity of the mating structure may still make it meaningful to excite each point simultaneously with an appropriate phasing. For example, a resistor mounted to terminals by symmetrical leads may be excited in-phase at the two terminals for investigation of a translational resonance, and out of phase for a rotational resonance.

An infinite impedance source may be simulated by using a rigid and massive vibration table or by holding the acceleration constant with frequency and independent of the part under test with the aid of a rigidly mounted accelerometer. A zero impedance source may be simulated by holding the applied force constant with the aid of a strain gage on a coupling element of fixed compliance.

System resonances may also be informative to measure, and this can be done by a number of appropriate techniques, but caution should be used in attributing a system resonance frequency to any one part, especially when loading effects are not known to be negligible.

Control of mechanical impedance

It was mentioned earlier that there is greater chance of damage when shock and vibration are propagated through a component in the direction of decreasing mechanical impedance. If successive resonances are close together in frequency, a whipping effect takes place at the end of the propagation path. In fact, the motion of a whip is an excellent example of propagation in a mechanical system (of distributed constants) in the direction of decreasing mechanical impedance such that a relatively gentle motion applied at one end generates a violent response at the other. Propagation of a disturbance in the reverse direction is more difficult.

One of the objections frequently mentioned in connection with raising the structural resonances of a chassis above the part resonances is the excessive weight that may result. This is partly illusory, because removing weight in an antinodal region raises rather than lowers the corresponding resonance. Nevertheless, as the size of the item to be stiffened increases, the weight penalty for a given minimum resonance frequency increases more than proportionately. Eventually the dimensions become greater than the corresponding wavelength in the structural material so that the minimum frequency can not be attained by any design technique. Extreme attempts at stiffening result unfortunately in a framework of high mechanical impedance such that if its resonances should still happen to coincide with any part resonances there may be extreme sensitivity to shock and vibration. It may therefore be more practical to design large electronic equipments as a collection of smaller assemblies meeting a minimum resonance frequency requirement and of dense (high mechanical impedance) construction, mounted to a framework of relatively

SCHAEVITZ ROTARY ACCELERATORS

THE EXACT TYPE OF ROTARY ACCELERATOR FOR YOUR REQUIREMENTS . . .

THIS SCHAEVITZ ROTARY ACCELERATOR IS A STANDARD IN THE FIELD OF ACCELERATION TESTING. THIS RECOGNITION CAN BE ATTRIBUTED TO VARIOUS FACTORS VITAL TO ENVIRONMENTAL TEST EQUIPMENT OF THIS TYPE.

FEATURES

- CONVENIENCE AND SAFETY IN USE
- ACCURATE SPEED CONTROL
- ACCURATE TRANSMISSION OF SIGNAL VOLTAGES
- REMOTE ELECTRONIC CONTROL CONSOLE
- OPTICAL AND PRESSURE SYSTEMS OPTIONAL
- TEST TO MIL. SPEC. MIL-E005272B (USAF)
- WIDE RANGE OF SIZES

ELECTRONIC CONTROL CONSOLE

Set speed is precisely maintained by a new electronic full-wave controller designed by Schaevitz especially for the purpose. Maximum use is made of solid state and magnetic amplifier components to insure stability and reliability.

SPEED MEASUREMENT

Digital readout using a pulse generator and a 4 decade electronic counter.

SLIP RINGS

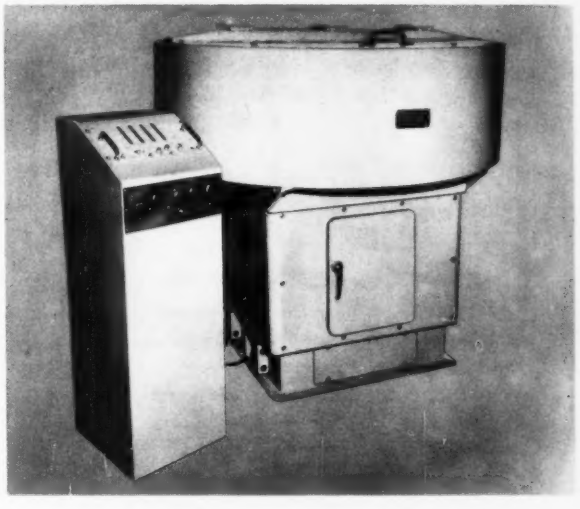
All standard slip rings are coin silver-faced with three silver graphite brushes per ring. Instrument rings with shielded leads are rated for 5 amperes at 110 volts and power rings are rated for 20 amperes at 280 volts.

SAFETY GUARD

In acceleration test procedure, safety of personnel is a most important consideration in the event of a breakdown of the equipment being tested. To eliminate danger, heavy steel safety guards with hinged and bolted covers are provided.

OPTICAL SYSTEM

Schaevitz Machine Works has developed an optical system with a wide field and a large depth of focus so that the rotating objects may be viewed as if stationary.



PRESSURE AND VACUUM SYSTEMS

Schaevitz accelerators may be equipped to provide pressure or vacuum at the rotating arm resulting in a convenient means of testing and calibrating pressure-measuring equipment under various conditions of acceleration. As many as six lines can be provided.

SPECIFICATIONS

RANGE OF GS

0 - 1000 - Electronic Drive
0 - 20,000 - Air Drive

OBJECT SIZE RANGE

1 inch diameter cyclinder 1 inch long and 4 oz. to a 5 ft. cube weighing 1000 lbs.

WORKING RADIUS

8 inches to 35 feet depending on model.

SPEED

0 - 1900 RPM - Electronic Drive
0 - 15,300 RPM - Air Drive

Whether your need is for a standard accelerator or a "Special", Schaevitz know-how and experience will produce the best accelerator for your requirements.

DATA SHEETS ARE AVAILABLE ON OUR COMPLETE RANGE OF SIZES AND WILL BE SENT UPON YOUR REQUEST.

schaevitz machine works

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light (low impedance) construction, and interconnected by cables or wires so tied down and supported at their ends, and with sufficient slack that they receive negligible stress from any flexing of the framework. As one extreme approach, the interior of these assemblies can be potted, although this is not necessary in principle. Since the framework has a low mechanical impedance by comparison with that of the assemblies, it can resonate in the range of the part resonances with less chance of damaging the parts.

In the foregoing, the phrases "high impedance" and "low impedance" have been used somewhat loosely. The impedance of an item in a frequency range that includes one or more resonances varies widely with frequency, the range between the extremes being determined primarily by the damping. To say, under such circumstances, that one item has a lower impedance than another at the points at which they come in contact may mean that the average impedance tends to be lower in the one, or, more precisely, that the impedance tends to be lower at the critical frequencies of interest, defined by reference to the frequencies of resonance in the two items.

It should not be inferred that propagation of shock and vibration in the direction of increasing mechanical impedance is always safe. Either trend may be dangerous, depending on the magnitudes of the impedances of the source of excitation, of the part that may fail, and sometimes of an intermediate structure. For example, consider an airplane whose source of excitation is high intensity sound outside the skin, and which carries an electronic device fastened to a main spar. The construction of the electronic device that would be most likely to result in failure in case of coincidence of internal resonances would be a gradual transition from the high impedance spar to low impedance electronic parts. On the other hand, the airplane construction that would result in the greatest vibration of the spar would be a gradual transition from a low impedance skin to the high impedance spar.

Isolation mounts

The isolation mount, also called vibration mount or shock mount, is an example of a device used in the transmission path of shock and vibration to maintain over a wide frequency range a mechanical impedance that tends to be low by comparison with the impedances of both items it separates. Under favorable circumstances this impedance discontinuity can be made to attenuate vibration or shock propagated in either direction.

The isolation mount is essentially a damped compliance of such magnitude that it introduces a system resonance in a low frequency range where the item isolated behaves much like a rigid body. The transmissibility* through the mount is invariably unity at zero frequency. With increasing frequency, the transmissibility ordinarily remains above unity and increases uniformly to a maximum at the resonance frequency and then decreases somewhat more rapidly to unity. The range below this unity point will be referred to as the *low frequency range* of the mount, and the range above as the *high frequency range* of the mount. In the latter, the mount normally functions as a low impedance element by comparison with the items it separates and provides some effective isolation. However, it may by accident couple with an efficiency comparable to that of a rigid coupling within a narrow frequency band if it is attached at either or both ends to an antinodal region.

**Ratio of acceleration response to applied acceleration.*

The mount itself because of its compactness and the materials used is less likely to exhibit standing wave phenomena than a chassis frame tuned at its first resonance to the same low frequency. In the low frequency region, the mount provides no isolation, but makes the vibration of the mounted equipment worse. Furthermore, the amplitude of the equipment motion may be sufficient to cause bottoming of the mount and consequent scattering of energy from the low frequency region into the high frequency region where it will be likely to result in damage.

Thus, an isolation mount is almost always an asset in the high frequency range and always a potential liability in the low frequency range. A corrolary is that it is always a potential liability under conditions of sustained high acceleration. Where the liabilities can be tolerated, the asset may justify the use of the isolation mount.

For best results, it is best to design the equipment and its isolation mount as a system. This imposes primarily one additional requirement on the component, that it have no internal resonances in the low frequency range of the mount, and preferably none within a factor of two or more of the mount resonance, except in some types of cabling. Cabling is preferably unstretched and in most cases preferably flexible to avoid stresses due to any flexing of the component structure. The ends of the cables must be supported so that gross motion of the cable does not stress the electrical connections. The body of the cable should never be far from the potential support in all directions but will not be hurt by bottoming against its supports.

If the resonances of the component are thus sufficiently high, little damage is likely to result from any excitation in the low frequency

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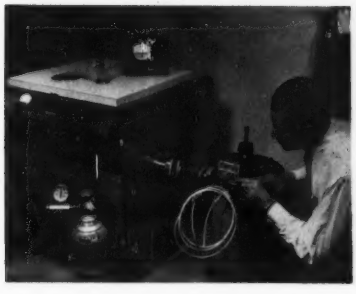

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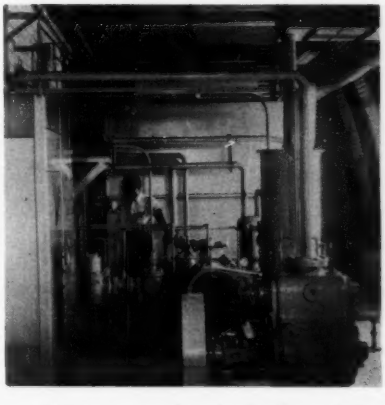

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range, short of bottoming of the mount. Damage is likely to result from any such bottoming. The danger of bottoming increases as the low frequency vibration becomes more vigorous, as the resonance frequency of the mount is decreased, and as the excursion of the mount is limited. A large permissible excursion in the mount carries significant penalties in space, if not directly in weight, that make it unwelcome in missile applications. It therefore appears advisable to set the mount resonance nearer 30 cps than 10 cps or so as has been common in airplane practice, and to require that the equipment have no resonances below 60 cps or so.

As a further precaution, it may be desirable to carry out a centrifuge test of the equipment or a stress analysis to several times the maximum rms g transmitted through the low frequency region of the mount in service and greater than the maximum low-frequency value of the shock spectrum at the mount resonance frequency for any anticipated shocks. As a practical matter, it will be found that these precautions seldom involve a serious weight penalty.

The use of vibration mounts and designing the equipment and mounts as a system tends to make the design techniques discussed previously less critical, although it is unwise to neglect such techniques.

Finally, it should be stressed that the mount is an effective isolator only when its mechanical impedance is less than that of both items it separates. The isolation mount in an actual missile or airplane in the high frequency range may be somewhat less than that indicated by an ideal performance curve as obtained conventionally on a vibration table or calculated from simple theory. In evaluating the advisability of a mount in a missile or airplane application, it may be well to make an inspection of the mechanical impedance of the airframe where the mount is to be used. If the impedance of the airframe is nearly equal to that of the mount in the frequency range in which isolation is desired, the use of the mount may not be justified.

Measurement of mechanical impedance

It will be found convenient in most situations to measure mechanical impedance by direct application of its definition. Suppose, for example, that it is desired to measure the mechanical impedance of an electronic equipment at its mounting point, and also that of the airframe where the equipment is to be mounted. Each measurement can be made by exciting the point of interest sinusoidally by an electrodynamic vibration table carrying suitable instrumentation. The magnet of the vibration table should be supported independently of the item to be tested, or suspended on a very soft mount for the duration of the measurement. Ordinarily, a simple linkage or adapter is necessary to couple the vibration table to the airframe or component. This can be designed to incorporate, as close to the excitation points as possible, a compliance carrying a strain gage and calibrated to provide a measure of the applied force. An accelerometer or velocimeter immediately beyond (on the output side of) the compliance will provide a measure of the response induced in the point of excitation. The ratio of the applied force to the velocity induced is the mechanical impedance of the item tested.

If desired, the reactive and resistive components of the impedance can be obtained through the use of some additional electronic apparatus. A phase sensitive detector controlled by the velocity signal can be made to separate the force signal into an in-phase component and an out-of-phase component. The ratio of the former to the velocity is the mechanical resistance. The ratio of the latter to the velocity signal is the mechanical reactance. The velocity signal may be obtained by integrating an accelerometer signal electrically or by calculation. The phase detector may alternately be controlled directly from an accelerometer if the phase convention is reversed. Electronic devices are available commercially for measuring voltage ratios and indicating them on direct reading meters.

To predict precisely and in detail the vibration of the equipment, as mounted in the airframe, from measurements made prior to installation, it is necessary to know at least four things, a forcing function as a function of frequency at the airframe mounting point, the impedance of the airframe and equipment as a function of frequency with phase information, and the transmissibilities or related measures of response within the equipment. The last is not necessary if the immediate objective is only to predict the vibration at the mounting point after installation. If the ratio of the magnitudes of the two impedances is greatly different from unity neither impedance and neither phase need be measured precisely as a rule to provide a basis for decisions. If the equipment impedance is by far the greater, the applied force will be independent of the ratio of impedances. If the component impedance is by far the smaller, the applied acceleration will be independent of this ratio. Frequently, enough information for practical purposes can be obtained from a casual qualitative inspection of the frequency plots.

The impedance of a part such as an isolation mount, that is a portion of the transmission path of shock or vibration involves a further clarification. Such a part, from the simplest point of view, has two mount-

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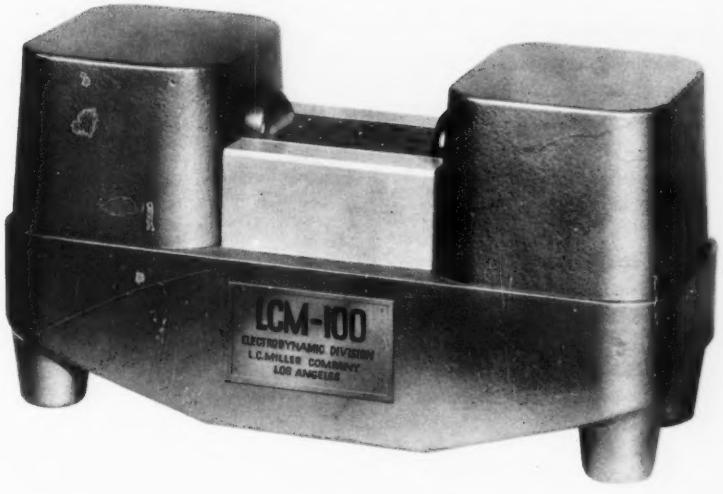

The LCM 100* is a new type of vibration exciter which features a horizontal, air supported, push-pull driven table. Although primarily designed for the *production testing* of components and small subassemblies, the unit's wide frequency range (5 to 15,000 CPS) and high force output will make it an ideal *research tool* for the product design engineer. The ruggedly built instrument is simple to operate, thus avoiding possible damage by inexperienced personnel.

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ing points. When the impedance at one of these is measured, the other must be "terminated" properly. In other words, if the extra mounting point has the character of a spring or a damper, it should be fastened to something that will remain stationary or "terminated in an infinite impedance". If, on the other hand, it has the character of a mass, it should be left free or "terminated in a zero impedance". As a practical matter, the impedance of a simple isolation mount by itself probably seldom needs to be measured directly, since it is readily calculable when desired from the compliance and damping.

Electrical analogies

Mechanical impedance is of course analogous to electrical impedance. Since the differential equations of mechanical systems are of essentially the same form as those of electrical circuits, it is possible to set up analogies* to such an extent that any given mechanical system can be solved in terms of an equivalent electrical circuit. Thus, the entire wealth of circuit theory becomes available as a tool for the mechanical designer. Furthermore, it frequently becomes easier to interpret the mechanical motions by inspection of the equivalent circuit than by inspection of the mechanical system itself. The mechanical design of an electronic chassis is sometimes controlled by a mechanical engineer and sometimes by an electronic engineer. The latter is entirely familiar with electrical resonance, but may have little intuitive feeling for mechanical resonance. A little meditation on analogies, particularly with the aid of a few representative numbers, may aid him greatly in visualizing the dynamical problem of shock and vibration, and may greatly increase his interests in the problems.

Reference 1

There is more than one way in which a set of analogies between electrical and mechanical systems can be set up. Perhaps the most obvious is suggested by Table I. A mechanical system with lumped constants becomes equivalent to a network of coils, capacitors, and resistors. A mechanical system with distributed constants becomes analogous to a transmission line.

TABLE I

Electromechanical Analogies	
Mechanical Element	Electrical Analog
Mass	Inductance
Compliance	Capacitance
Damping	Resistance
Force	Voltage
Velocity	Current
Displacement	Charge
Acceleration	Time derivative of current

Conclusion:

An attempt has been made to outline a number of useful criteria for hardware design, extending beyond those commonly in use, that assist in providing resistance to shock and vibration. Particular emphasis has been placed on relationships of resonant amplification, resonance frequencies, and mechanical impedance. For the most part the treatment has been qualitative. With the aid of a more systematic study than has been carried out to date on the resonances and impedance characteristics of electronic parts and supporting members, according to current design practices, it may be possible to develop such criteria into more practical and quantitative rules for design. As limited by the functional requirements, the criteria may also find application in the design of electromechanical and hydraulic devices.

It will be noted that the treatment was primarily in terms of vibration as transmitted to equipment by an airframe as opposed to that transmitted by a vibration table or other test device. This permitted a more general and basic approach. Within the limitations of permissible complexity of test apparatus and simulation procedures, there has been developed no practical method of accounting in test for any effects of the relationship between the equipment impedance and the airframe impedance except by sometimes specifying spectra of force rather than acceleration, and on the basis of occasional deviations from specifications. This situation may change after further investigation.

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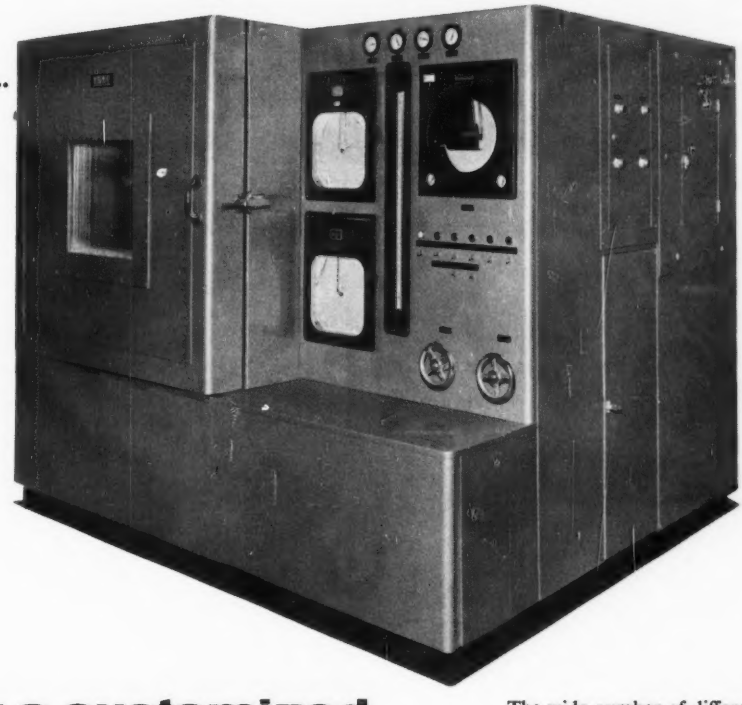

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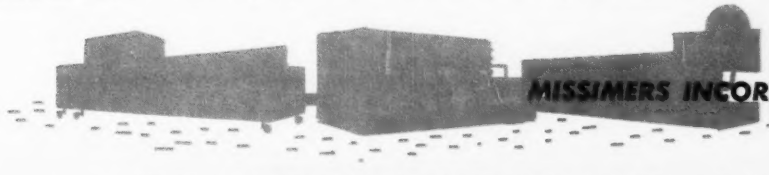

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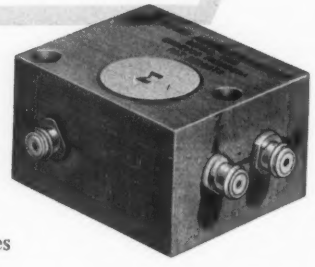

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Continued from page 1

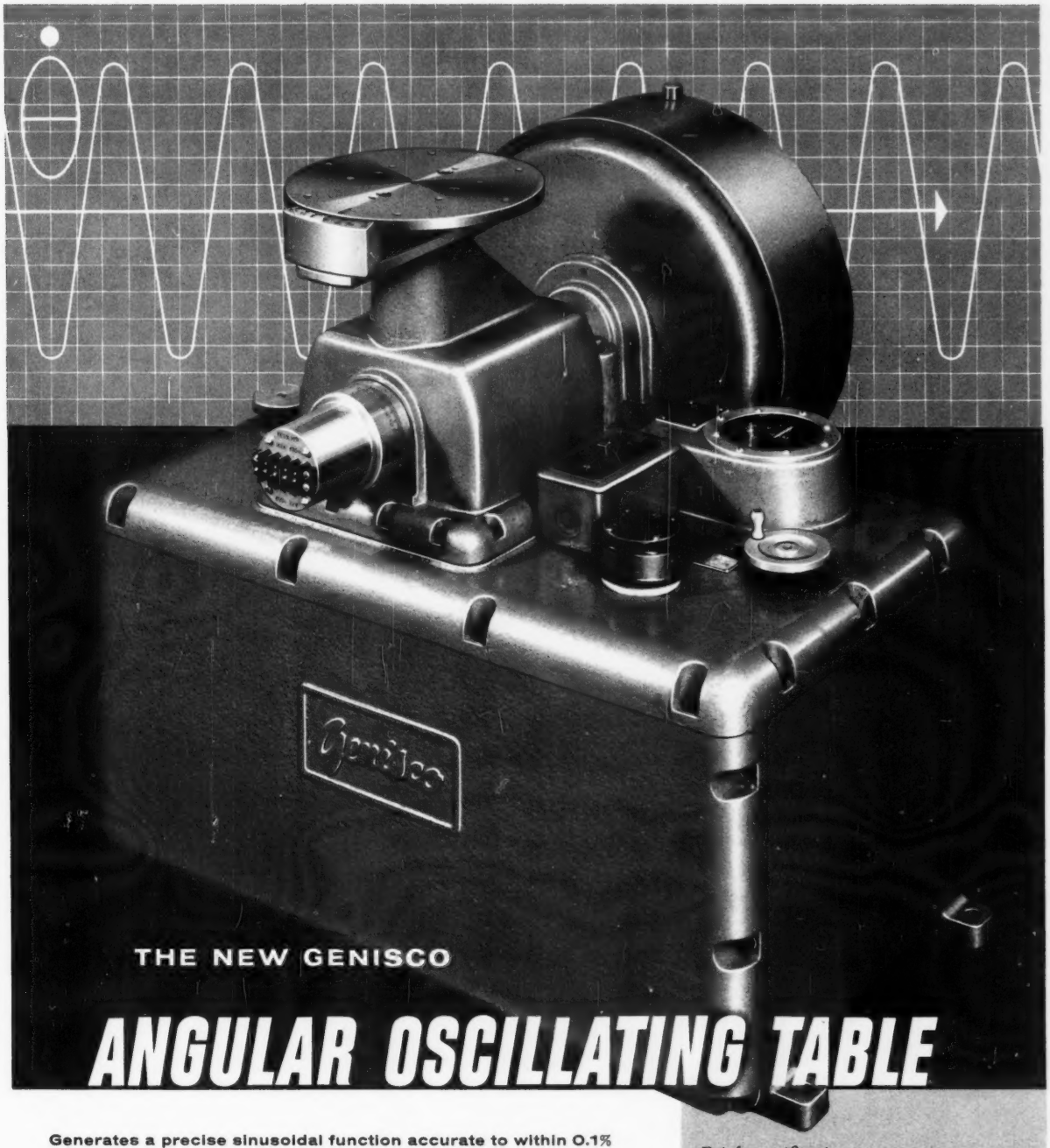
Our NEWSLETTER really grew up with the publication of the first issue of the JOURNAL OF ENVIRONMENTAL ENGINEERING in October. Frank Kramer, our Publications Committee Chairman, deserves special commendation for this. He then followed-up with the second issue right on schedule in December. Not only did this equal the high standard of quality set by the first issue, but it was even able to show improvements. This was a big stride forward for SEE.

Mr. Frank Oliver, Editor of ELECTRICAL MANUFACTURING, attended our June 2 meeting, while on a tour of the West Coast. His observations of that tour and SEE were discussed in the editorial in the August issue of that magazine.

The SEE Employment Referral Service was initiated. This has enjoyed moderate activity. As a rule, more jobs have been listed than applications for jobs.

People in England, Canada, Colorado, Utah, Arizona, San Diego, and Palo Alto have expressed interest in our Society. We have given them all the information available and offered to assist them in setting up their own groups. We also proposed to cooperate as closely as possible with these groups without setting up a central organization to direct the several chapters. We don't feel that we are ready for this, or that the added expense would prove worthwhile.

Much credit is due the Board of Directors for 1958. Seldom is such a group so willing to devote time and effort. It has made the job of Chairman a very pleasant one. On many occasions, special meetings and special assignments have been necessary and have been attended or carried out willingly and effectively. I am sure with the new Board under the leadership of Jerry Bakalish that SEE will continue to improve and expand in 1959.



THE NEW GENISCO

ANGULAR OSCILLATING TABLE

Generates a precise sinusoidal function accurate to within 0.1% at excursions up to ±2°, 0.5% up to ±10°, and 1% up to ±15°.

This newest Genisco machine utilizes a unique conical crank mechanism to generate an angular oscillation which closely corresponds to a theoretical sinusoidal waveform. A precision sine-cosine resolver coupled to the crankshaft can be used to bring a test instrument output signal and the oscillating table output signal into coincidence for direct reading of phase lag angle.

The extreme accuracy of the Model B386 Oscillating Table makes it particularly suited for evaluating the damping and response characteristics of angular accelerometers and rate gyros. The Model B386 can also be used for calibrating peak angular velocities and peak accelerations to the accuracy of the known angular excursion and frequency. Within its range, the machine can double as an environmental angular shake table.

For complete information and performance specifications, write to–

Brief specifications

Angular Excursion: Infinitely adjustable from zero to ±15°.

Frequency Range: Continuously variable from 0.02 to 3 cps in the low range; 0.2 to 30 cps in the high range.

Accuracy:
Angular Excursion – within 10 minutes of arc.
Frequency Indication – within 1% with tachometer; within 0.1% with stroboscope.

Payload Capacity: 100 lb. deadweight; 750 lb.-in. under dynamic conditions. Protected against dynamic overload by replaceable shear pins.

Vibration Isolation:
Vertical Displacement – 0.003" max. at any frequency.
Lateral Displacement – 0.001" max. at any frequency.

Platform Diameter: 8".

Approx. Weight: 400 lb.

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Whether you think of vibration testing as a means of prototype shake-down, or as a full quality control test on production runs, there's a Ling system for the job. Parts, components or even an entire missile, airplane or other major package can be tested to desired specifications with one of Ling's line of complete systems.

These systems include high-powered vibration generators with output ratings from 1 to 90 KVA, operating consoles, electro-mechanical shakers and accessory equipment as necessary for any specific test requirement.

Ling vibration systems are capable of producing a wide variety of tests, ranging from simple sine-wave sweeps to the exact reproduction of random or complex vibrations which are tape recorded from actual missile flights.

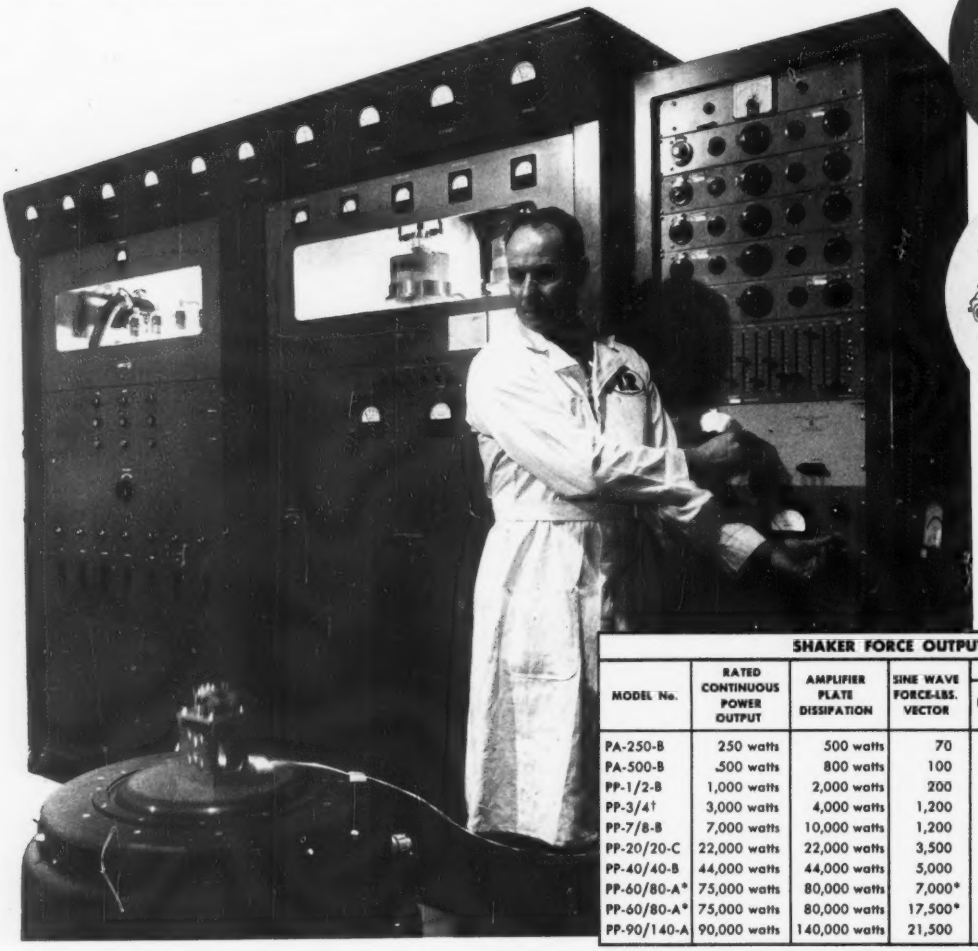
Among the new developments in high powered electronics by Ling is a packaged vibration test system—the Sine-O-Matic. This compact unit contains everything necessary for fully automatic or programmed sine wave testing in a single, desk-type console. Only the shaker is separate.

Another example of Ling's leadership is a complete mobile testing laboratory capable of field testing an entire airplane, missile or any large component. Ling sales engineers will be happy to discuss your own vibration testing requirements, whether for a standard system or in solving advanced vibration test problems.

Model PP-90/140

Sine-O-Matic †
Model PP-3/4

Mobile Vibration Laboratory



This 20 KVA power generator and control console at Rocketdyne is one of 23 complete Ling systems at North American Aviation Divisions.

SHAKER FORCE OUTPUT						
MODEL No.	RATED CONTINUOUS POWER OUTPUT	AMPLIFIER PLATE DISSIPATION	SINE WAVE FORCE-LBS. VECTOR	RANDOM NOISE		ARMATURE PROTECTOR MODEL REQUIRED
				FORCE-LBS. RMS	FORCE LBS. PEAK	
PA-250-B	250 watts	500 watts	70	—	—	—
PA-500-B	500 watts	800 watts	100	—	—	—
PP-1/2-B	1,000 watts	2,000 watts	200	—	—	—
PP-3/4†	3,000 watts	4,000 watts	1,200	—	—	—
PP-7/8-B	7,000 watts	10,000 watts	1,200	840	2,520	AP-10-A
PP-20/20-C	22,000 watts	22,000 watts	3,500	2,500	7,500	AP-30-A
PP-40/40-B	44,000 watts	44,000 watts	5,000	3,500	10,500	AP-40-A
PP-60/80-A*	75,000 watts	80,000 watts	7,000*	5,000*	15,000*	AP-60-A
PP-60/80-A*	75,000 watts	80,000 watts	17,500*	12,000*	36,000*	AP-60-A
PP-90/140-A	90,000 watts	140,000 watts	21,500	14,000	42,000	AP-60-A

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